TECHNICAL MEMORANDUM – DRAFT

Date: July 24, 2006

To: Jeremy Lowe, PWA

From: David Pohl, PhD., P.E.
Cathy Hartman

Subject: Summary of Results from Sediment Sampling and Analysis in Area B – Ballona Marsh

Purpose of Sediment Investigation

The Draft Ballona Wetland Existing and Historical Conditions Report presented a summary of the available water and sediment quality data for the Project Area and also identified several data needs/gaps in Section 5. One of the unknown factors in the assessment was the sediment quality in the existing tidal marsh within Area B (Ballona Marsh). Although sediment quality results were available from the Ballona Creek estuary, a direct correlation to the current sediment characteristics in Area B could not made due to the significant difference in long-term loading history of these sediments. The sediments in the tidal marsh have experienced muted tidal flows and subsequent reduced constituent loadings while sediments in the Ballona Creek estuary have been subject to the full storm flows and constituent loadings from the entire Ballona Creek watershed. Sediment quality data from Area B is needed to characterize the current baseline condition and evaluate the long-term quality of sediments in the restoration areas and potential impacts to the wetland species.

Sample Location and Study Methods

Eight stations located within Area B were sampled by the City of Los Angeles Department of Sanitation for sediment quality on May 5, 2006 (Figure 1).

Sediments from Area B were analyzed for metals, PAHs, pesticides, PCBs, grain size, and toxicity. Most of the stations (BWS-3, 4, 5, 9, and 10) are within Area B's east channel between Ballona Creek and Culver Blvd. The east channel is connected to Ballona Creek by self-regulating tide gates which allow for muted tidal flow. One station, BWS-1, is located within the west channel, which is connected to Ballona Creek by a 36' pipe with a flap gate on the creek side which prevents tidal flows in while allowing drainage to occur. BWS-8 is located on the southeastern side of Culver Blvd., where it may be influenced by freshwater seeps. BWS-11 is located on the northwestern side of Culver Blvd. where it is likely influenced by storm water and urban runoff.

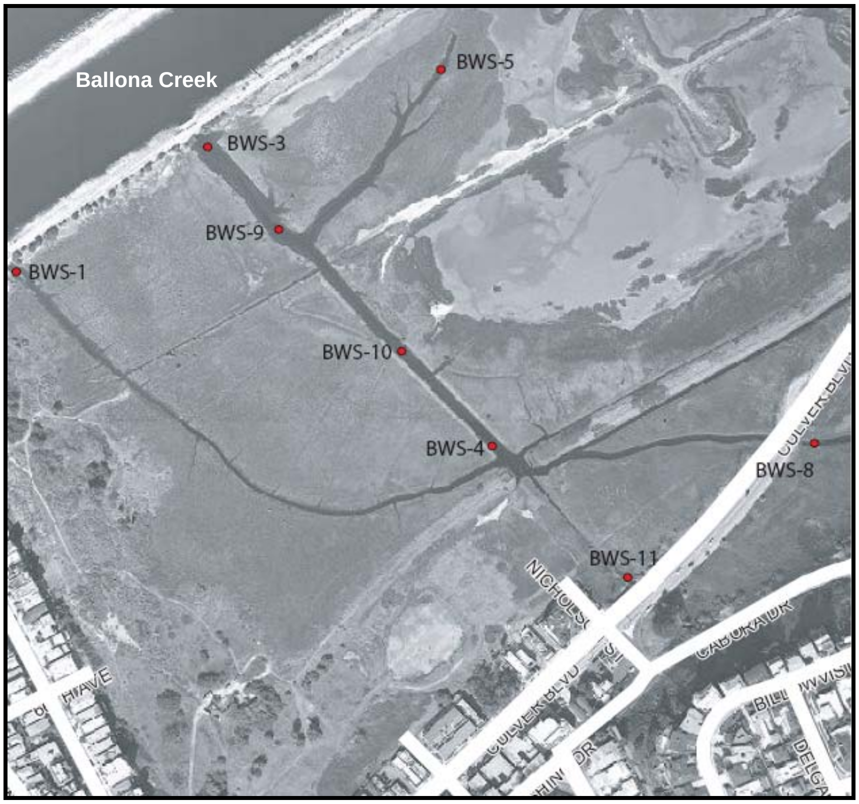

Figure 1. Sediment Quality Sampling Stations within Area B.

Currently, there are no universally accepted criteria for assessing contaminated sediments. However, the Effect Range Low (ERL) and Effect Range Median (ERM) values originally developed by Long and Morgan (1990) and subsequently revised and expanded upon by Long and MacDonald (1992) and Long et al. (1995) can be used to evaluate the potential for sediment to cause adverse biological effects (Table 1). These parameters were developed from a large data set where results of both sediment toxicity bioassays (e.g., amphipod tests) and chemical analyses were available for individual samples. The guidelines were intended to provide informal (non-regulatory) effects-based benchmarks of sediment chemistry data (Long et al. 1998). Two effects categories have been identified:

ERL – Effects Range Low: concentrations below which adverse biological effects are *rarely* observed and therefore provides a conservative benchmark; and

ERM – Effects Range Medium: concentrations above which adverse biological effects are more frequently, though not always observed.

Sediment chemistry data from samples collected in Area B were compared to the ERM and the more conservative ERL. In addition, for each sediment sample, ERM values were used to calculate a mean ERM quotient (ERM-Q). The concentration of constituents tested was divided by its ERM to produce a quotient, or proportion of the ERM equivalent to the magnitude by which the ERM value is exceeded or not exceeded. The mean ERM-Q for each sample was then calculated by summing the ERM-Qs for selected constituents, and then dividing by the total number of ERM-Qs assessed. ERM-Qs were not calculated for constituents below the detection limit and thus were not used in the generation of the mean ERM-Q. The mean ERM-Q thus represents an assessment for each sample of the cumulative sediment chemistry relative to the threshold values. In this way, the cumulative risks of effect to the benthic community can provide a mechanism to compare channels within the existing marsh to the creek. This method has been used and evaluated by several researchers (Hyland et al. 1999, Carr et al. 1996, Chapman 1996, and Long et al. 1995) throughout the country.

The aggregate approach using an ERM-Q is a more reliable predictor of potential toxicity but should not be used to infer causality of specific contaminants. ERL and ERM values were originally derived to be broadly applicable and they cannot account for site-specific features that may affect their applicability on a more local or regional level. Local differences in geomorphology can result in chemicals being more or less available and therefore more or less toxic than an ERL or ERM value might indicate. Additionally, some regions of the country are naturally enriched in certain metals and local organisms have become adapted.

Table 1. Sediment Effects Guideline Values.

Parameter	Effects Range-Low (ERL)	Effects Range-Median (ERM)
Metals (mg/Kg)		
Antimony	2.0	2.5
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Lead	46.7	218
Nickel	20.9	51.6
Zinc	150	410
Organics (µg/Kg)		
Acenaphthene	16	500
Acenaphthylene	44	640
Anthracene	85.3	1,100
Fluorene	19	540
Naphthalene	160	2,100
Phenanthrene	240	1,500
Low-molecular weight PAH	552	3,160
Benz(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Pyrene	665	2,600
High molecular weight PAH	1,700	9,600
Total PAH	4,022	44,792
Total PCBs	22.7	180

Source: Long et al. 1995
ERL = Concentration at lower tenth percentile at which adverse biological effects were observed or predicted.
ERM = Concentration at which adverse biological effects were observed or predicted in 50% of test organisms.
mg/Kg = milligrams per kilogram.
µg /Kg = micrograms per kilogram.

Summary of Analytical Results

Sediments from Ballona Marsh were analyzed for four groups of constituents: metals, PAHs, pesticides, and PCBs. The key question of this sampling effort was whether known impacted waters from Ballona Creek have also impaired the sediments in the tidal channels within Area B. Concentrations of chemical constituents were expected to be greater in the Ballona Creek estuary sediments compared to Area B, due to greater overall loading from the Ballona Creek watershed. Flow into the existing tidal marsh of Area B has been restricted by tidal gates, and is from the creek estuary where mixing of the fresh water creek flows with the salt water of Santa Monica Bay occurs. However, wetlands are known to act as a sink for lower mobility constituents such as heavy metals and semi-volatile compounds that include PAHs. Additional questions that were to be investigated were whether there was evidence of impacts from historical uses of portions of Area B for agricultural purposes (bean cultivation) and from urban runoff. Area B is subject to urban runoff flows from adjacent residential communities and transportation corridors (Culver Blvd.). Table 2 presents the results of the chemical analysis and toxicity testing.

Metals

The concentrations of metals detected in the sediments samples exceeded the ERM at two of the eleven stations. The concentrations of copper, lead and zinc in the sediment at Station BWS-11 located adjacent to Culver Boulevard were above the ERM indicating potential impact to the sediments. These three metals are typically found in urban runoff and are generally associated with automobile tires, brake pads and emissions. Although these metals are also found at concentrations above the water quality objectives in Ballona Creek, the location of this sample adjacent to Culver Boulevard suggests a direct impact from runoff from the roadway and from direct aerial deposition.

Table 2. Analytical Results for Ballona Marsh Sediments

Parameter	Units	MDL	ERL*	ERM*	BWS-1	BWS-3	BWS-4	BWS-5	BWS-8	BWS-9	BWS-10	BWS-11
Toxicity												
Mean *Eohaustorius estuarius* survival (relative to control)	%				94.79	98.96	91.67	**64.58**	96.88	**34.38**	**60.42**	**9.38**
Sediment Size and TOC												
Gravel	%				0	0	0	0	0	0	0	0
Sand	%				51.2	70.2	79.7	22.8	47.4	37	30.5	47.4
Silt	%				41.8	24	16.6	51.5	46.6	51.5	57.9	45.1
Clay	%				7.11	5.98	3.73	25.8	6	11.5	11.6	7.47
Median size	microns				66	250	360	13	56	40	28	56
Mean size	microns				110	470	470	5.9	140	60	55	55
Total Organic Carbon	%	0.001			0.919	0.777	0.372	0.597	1.15	1.04	0.41	4.64
Metals												
Arsenic	mg/kg	0.22	8.2	70	6.13	3.7	4.26	**12.4**	**10.3**	**8.45**	5.56	**14.6**
Cadmium	mg/kg	0.02	1.2	9.6	**2.39**	**2.12**	**1.83**	**4.5**	**4.66**	**3.67**	**3.32**	**6.16**
Chromium	mg/kg	0.1	81	370	29.2	21.9	18	70.2	52.1	35.4	33.4	64.3
Copper	mg/kg	0.18	34	270	**35.3**	30.6	17	**60.8**	**82.9**	**48.8**	**39.3**	**440**
Lead	mg/kg	0.15	46.7	218	46.6	26.9	20.8	**103**	**92.5**	**62.6**	24	**248**
Mercury	mg/kg	4E-04	0.15	0.71	0.122	0.065	0.041	**0.229**	**0.272**	0.143	0.0976	**0.29**
Nickel	mg/kg	0.2	20.9	51.6	16	13.4	9.2	**30.7**	**27.9**	20.5	**21.7**	**38.5**
Silver	mg/kg	0.02	1	3.7	**1**	0.43	0.27	**3.77**	**1.54**	**1.85**	0.43	0.46
Zinc	mg/kg	0.21	150	410	**155**	109	54.9	**190**	**330**	**192**	124	**1770**
Selenium	mg/kg	0.35			0.48	0.56	0.55	<0.35	1.61	<0.35	0.42	0.55

Parameter	Units	MDL	ERL*	ERM*	BWS-1	BWS-3	BWS-4	BWS-5	BWS-8	BWS-9	BWS-10	BWS-11
PAHs												
Total detectable PAHs	mg/kg		4.022	44.79	0	0	0	0	0	0	0	1.5
Pesticides & PCBs												
Total detectable DDT	ug/kg		1.58	46.1	**3.6**	**17.1**	0	1.2	**7.3**	**5.6**	1	**9.6**
Total detectable chlordane	ug/kg		0.5	6	**4.5**	**51.4**	0	**1.2**	**2.4**	**2.7**	**1.2**	**6.7**
OP Pesticides												
Azinphosmethyl (Guthion)	ug/kg	13.8			<13.8	<13.8	<13.8	<13.8	<13.8	<13.8	<13.8	<13.8
Bolstar	ug/kg	1.5			<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Chlorpyrifos (Dursban)	ug/kg	1.6			<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
Coumaphos	ug/kg	13.5			<13.5	<13.5	<13.5	<13.5	<13.5	<13.5	<13.5	<13.5
Def	ug/kg	3.5			<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5
Demeton (Total)	ug/kg	2.5			<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Diazinon	ug/kg	2			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dichlorvos	ug/kg	3.3			<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Dimethoate	ug/kg	4.91			<4.91	<4.91	<4.91	<4.91	<4.91	<4.91	<4.91	<4.91
Disulfoton	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
EPN	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Ethion	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Ethoprop	ug/kg	1.4			<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
Fensulfothion	ug/kg	18.7			<18.7	<18.7	<18.7	<18.7	<18.7	<18.7	<18.7	<18.7
Fenthion	ug/kg	2.7			<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7
Malathion	ug/kg	0.6			<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Merphos	ug/kg	4.5			<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5
Mevinphos	ug/kg	5.2			<5.2	<5.2	<5.2	<5.2	<5.2	<5.2	<5.2	<5.2
Naled	ug/kg	17			<17	<17	<17	<17	<17	<17	<17	<17
Parathion, ethyl	ug/kg	2.75			<2.75	<2.75	<2.75	<2.75	<2.75	<2.75	<2.75	<2.75
Parathion, methyl	ug/kg	3.4			<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4
Phorate	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Prowl (Pendimethalin)	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	300
Ronnel	ug/kg	1.4			<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
Stirophos	ug/kg	6.2			<6.2	<6.2	<6.2	<6.2	<6.2	<6.2	<6.2	<6.2
Sulfotep	ug/kg	1.14			<1.14	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14
Tokuthion	ug/kg	1.8			<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Trichloronate	ug/kg	1.3			<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Trifluralin	ug/kg	4.4			<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4
Pyrethroids												
Bifenthrin	ug/kg				ND	ND	ND	ND	ND	ND	ND	34J
Cyfluthrin	ug/kg				ND	ND	ND	ND	ND	ND	ND	ND
Cypermethrin	ug/kg				ND	ND	ND	ND	ND	ND	ND	ND
Esfenvalerate/Fenvalerate	ug/kg				ND	ND	ND	ND	ND	ND	ND	ND
Lambda cyhalothrin	ug/kg				ND	ND	ND	ND	ND	ND	ND	ND
Permethrin	ug/kg				ND	ND	ND	ND	ND	ND	ND	ND
PCBs												
Total detectable PCBs	ug/kg		22.7	180	16	**25**	0	0	0	**36**	0	**24**
Mean ERM quotient					0.22	0.80	0.07	0.32	0.32	0.26	0.15	0.84

MDL = Method Detection Limit is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, as defined in 40 CFR Part 136 Appendix B.

* Effects Range-Low and Effects Range-Median (Long et al. 1995)

Toxicity results in **bold** = moderately toxic (per Bight criteria)

Toxicity results in **bold** = highly toxic (per Bight criteria)

Chemistry results in **bold** = exceeds ERL

Chemistry results in **bold** = exceeds ERM

J - Estimated value

The other sediment sample that was observed to exceed the ERM was at BWS-5 for silver. The more conservative ERL benchmark was exceeded at numerous locations as shown on Table 2. The greatest number of exceedances is observed at Stations BWS-5, -8, -9 and -11. A summary of the results are presented below.

- *Arsenic* concentrations were above the more conservative ERL benchmark of 8.2 mg/kg at four stations; BWS-5, BWS-8, BWS-9, and BWS-11. Values ranged from 8.45 to 14.6 mg/kg at BWS-11. However, none approached the 70 mg/kg ERM.

- *Cadmium* concentrations were above the more conservative ERL of 1.2 mg/kg at all stations sampled. Values ranged from 1.83 mg/kg at BWS-4 to 6.16 mg/kg at BWS-11. However, none exceeded the ERM value of 9.6 mg/kg.

- *Copper* concentrations were above the ERL benchmark of 34 mg/kg at six out of eight stations. The concentrations at these stations ranged from just above the ERL at BWS-1 to 83 mg/kg at BWS-8. The concentrations were above the ERM of 270 mg/kg at BWS-11 with a detected value of 440 mg/kg.

- *Lead* concentrations were above the more conservative ERL of 46.7 mg/kg at four stations that included BWS-5, -8, -9 and -11. However, there the ERM of 218 mg/kg was exceeded at only at BWS-11 (248 mg/kg).

- *Mercury* concentrations were above the ERL of 0.15 mg/kg at three stations but had no exceedances of the ERM of 0.71 mg/kg. Exceedances at stations BWS-5, -8, and -11 ranged from 0.229 to 0.29 mg/kg.

- *Nickel* concentrations were above the more conservative ERL of 20.9 mg/kg at four stations. Exceedances at stations BWS-5, -8, -10, and -11 ranged from a low of 21.7 mg/kg at BWS-10 to a high of 38.5 mg/kg at BWS-11. The 20.5 mg/kg detected at BWS-9 fell just below the ERL. Nickel was not detected at any stations at levels above the ERM.

- *Silver* was detected at levels above the more conservative ERL of 1 mg/kg at four stations, including one exceedance of the ERM of 3.7 mg/kg. Stations BWS-1, -8, and -9 were each detected at concentrations between 1 and 1.85 mg/kg. The single exceedance of the ERM was at BWS-5, at which a concentration of 3.77 mg/kg was detected.

- *Zinc* exceeded the ERL of 155 mg/kg at five stations, including one exceedance of the ERM of 410 mg/kg. Samples collected from stations BWS-1, -5, -8, and -9 were each found to have concentrations between 155 mg/kg at BWS-1 and 330 mg/kg at BWS-8. The single exceedance of the ERM was at BWS-11, where a concentration of 1,770 mg/kg was detected.

PAHs
Total detectable PAHs were only detected at BWS-11 with a value of 1.5 mg/kg, below the ERL of 4.02 mg/kg. The results indicate no impact to the sediments of Area B from PAHs.

Pesticides
The concentration of organochlorine pesticides (OP pesticides) in the sediment samples in Area B exceeded the ERM at two (BWS-3 and -11) of the eleven locations for total detectable chlordane. Station BWS-3 is located adjacent to the tide gate in the main channel. Due to the location of this sample, the results indicate a potential impact from waters of Ballona Creek on the sediment near the tide gates with regard to chlordane. There were no other exceedances of the ERM in the main channel, and the concentrations of chlordane deceased in the main channel with greater distance from the tidal gate. The exceedances at BWS-11 of the ERM may be the result of impact from urban runoff at this location adjacent to Culvert Blvd. There were no other detections of pesticides above the ERM.

Other organochlorine pesticides detected, for which there are no current ERL/ERM guidelines, include nonachlors, enfosulfans, and oxychlordane. Cis-nonachlor was detected at station BWS-3, at a concentration of 5.4 µg/kg and at BWS-11 at a concentration of 2.9 µg/kg. Trans-nonachlor was detected at six of the eight stations at values ranging from a low of 0.4 µg/kg at BWS-5 to a high of 16.6 µg/kg at BWS-3. No nonachlors were detected at BWS-4 or BWS-8. Endosulfan I was detected at BWS-1 at a concentration of 0.6 µg/kg. Oxychlordane was detected at BWS-11 at a concentration of 1.3 µg/kg. OP pesticides and pyrethroids were also detected at BWS-11.

Total detectable DDT exceeded the ERL at five stations, BWS-1, -3, -8, -9, and -11, with values ranging from 3.6 µg/kg at BWS-1 to 17.1 µg/kg at BWS-3. Total detectable DDT was below the ERL value at BWS-5 and BWS-10 and was not detected at BWS-4. No levels were detected above the ERM of 46.1 µg/kg.

Total detectable chlordane exceeded the ERL of 0.5 µg/kg at seven out of eight sampled stations and the ERM of 6 µg/kg at two stations. No chlordanes were detected at BWS-4. The ERM was exceeded at BWS-3 and BWS-11, with respective values of 51.4 µg/kg and 6.7 µg/kg.

Dieldrin was detected in three of the eight stations sampled. Values above the ERL of 0.02 µg/kg ranged from 1 µg/kg at BWS-9 to 1.3 µg/kg at BWS-1 to 2.4 µg/kg at BWS-3. The remaining five stations were non-detect, however, the method detection limit for this constituent was 0.8 µg/kg, a higher value then the ERL. These five stations may in fact have exceeded the ERL if they were between 0.02 and 0.8 µg/kg. No samples exceeded the ERM of 8 µg/kg.

One OP pesticide and one pyrethroid were detected at levels above their method detection limits at BWS-11. Prowl (pendimethalin) was detected at concentrations of 300 µg/kg and bifenthrin at an estimated value of 34 µg/kg. These analytes are emerging contaminants of concern and do not have established ERLs or ERMs. Pendimethalin is an OP pesticide known as Prowl that is used as an herbicide and is considered of low acute toxicity (http://www.epa.gov/epaoswer/hazwaste/minimize/factshts/pendmeth.pdf). Bifenthrin is a pyrethroid insecticide and miticide classified as "Restricted Use" due to toxicity to fish and aquatic organisms; its use is prohibited in areas where it may result in exposure of endangered species (http://www.fs.fed.us/foresthealth/pesticide/bifenthr.html). That these two pesticides were found only at BWS-11, where the primary influence is stormwater runoff and urban flows, may indicate that those flows are a transport mechanism. These constituents were not analyzed in sediments collected from the Ballona Creek estuary in 2003.

PCBs

There were no detections of PCBs in the sediment samples above the ERM. Total detectable PCBs exceeded the ERL of 22.7 µg/kg at three stations, BWS-3, BWS-9, and BWS-11. The exceedances ranged from 24 and 25 µg/kg at BWS-11 and BWS-3 to 36 µg/kg at BWS-9.

ERM –Q Results

ERM-Q values were above the threshold of 0.10 at seven of the eight stations monitored in Area B. Only BWS-4 had a mean ERM-Q value below 0.10, with a value of 0.07. The highest ERM-Q was calculated for the sediment samples from BWS-3 and BWS-11. As discussed above, the ERM-Q represents an assessment of the cumulative sediment chemistry relative to the threshold values. The high ERM-Q for BWS-3 is driven by the higher chlordane concentration. This sample is located the closest to the tide gates to Ballona Creek and therefore indicates a potential impact from tidal flows into the main channel from the creek. The ERM-Q for sample BWS-11 is driven by both metals and pesticide concentrations. BWS-11 is located adjacent to Culver Blvd and appears to be impacted by urban runoff. ERM-Q values for the samples between BWS-11 and BWS-3 along the main channel decease with distance from the tide gates (0.26, 0.15 and 0.07) indicating decreasing impact from Ballona Creek, and localized impact from urban runoff.

<u>Summary of Acute Testing Results</u>

The mean percent survival of the test organism, *E. estuarius,* exposed to Ballona Marsh sediments ranged from 9 to 99%. Percent survival was the lowest at stations BWS-9 and BWS-11, with values of 34% and 9%, respectively. Station BWS-9 is the second sampling location from the tide gates to Ballona Creek. The concentrations of metals, pesticides and PCBs in BWS-9 were not significantly greater than the other samples located in the main channel, and the ERM-Q of this sample was 0.26, compare to the ERM-Q of 0.80 at BWS-3 located closest to the tide gate. These results for BWS-9 suggest a possible constituent or physical condition that is resulting in toxic response as opposed to from the concentration of the constituents analyzed for this program. Further testing may be needed to determine the cause of the toxicity response.

The toxic response observed for BWS-11 corresponds to detected higher concentrations of metals and several pesticides in this sample. The toxicity results also correspond to the ERM-Q value for this sample, which is the highest of the eleven samples. The results for BWS-11, which is located in a tributary channel adjacent to Culver Blvd., indicate a potential impact from urban runoff that is resulting in toxic response to aquatic organisms.

The mean percent survival of *E. estuarius* at BWS-5 and BWS-10 were 65% and 61%, suggesting that the sediments in these areas were moderately toxic to the test organisms. The remaining stations had a mean percent survival range between 92 and 99%, which suggests that the sediments in this area did not demonstrate an acute toxic response.

Summary of Geotechnical Testing Results

Sand, silt, and clay were the dominant sediment constituents at the stations monitored in the Ballona Marsh. Sand dominated the sediment composition at five stations, BWS-1, -3, -4, -8, and -11, followed by silt. Silt was the dominant constituent at BWS-5, followed by clay, and at BWS-9 and -10, followed by sand. Median grain size ranged from 13 to 360 microns. TOC content ranged from 0.37 to 4.64%. Station BWS-4 had the largest median grain size and the lowest TOC content.

Conclusions

The key question of this sampling effort was:

Have known impacted waters from Ballona Creek also impaired the sediments in the tidal channels within Area B?

Concentrations of chemical constituents were expected to be greater in the Ballona Creek estuary sediments compared to Area B, due to greater overall loading from the Ballona Creek watershed. The results of this sediment sampling and testing program in Area B indicate that the sediment close to the tide gate is potentially impacted by pesticides, specifically chlordane and DDT from Ballona Creek. Concentrations of chlordane and DDT decrease in concentration with distance from the tide gates. The impact from Ballona Creek on the sediments in Area B with regard to metals is not conclusive, and the results indicate other sources of metals. The physical characteristics of the sediment also influence the concentration of metals detected. Sediment with higher fraction of clay (BWS-5) exhibit will exhibit a greater adsorption capacity for metals.

Additional questions that were to be investigated were whether there was evidence of impacts from historical uses of portions of Area B for agricultural purposes (bean cultivation) and from urban runoff. Area B is subject to urban runoff flows from adjacent residential communities and transportation corridors (Culver Blvd.). The following results of this investigation indicated a strong connection to exceedances of sediment guidelines and toxicity response to potential impacts from urban runoff:

- The concentrations of copper, lead and zinc in the sediment at Station BWS-11 located adjacent to Culver Boulevard were above the ERM indicating potential impact to the sediments. These three metals are typically found in urban runoff and are generally associated with automobile tires, brake pads and emissions. Although these metals are also found at concentrations above the water quality objectives in Ballona Creek, the location of this sample adjacent to Culver Boulevard suggests a direct impact from runoff from the roadway and from direct aerial deposition.

- The concentration of organochlorine pesticides (OP pesticides) in the sediment samples in Area B exceeded the ERM at two (BWS-3 and -11). The exceedances at BWS-11 of the ERM may be the result of impact from urban runoff at this location adjacent to Culvert Blvd.

These conclusions are further supported from the calculated ERM-Q. The highest ERM-Q was calculated for the sediment samples from BWS-3 and BWS-11. The ERM-Q represents an assessment of the cumulative sediment chemistry relative to the threshold values. The high ERM-Q for BWS-3 is driven by the higher chlordane concentration. This sample is located the closest to the tide gates to Ballona Creek and therefore indicates a potential impact from tidal flows into the main channel from the creek. The ERM-Q for sample BWS-11 is driven by both metals and pesticide concentrations. BWS-11 is located adjacent to Culver Blvd and appears to be impacted by urban runoff. ERM-Q values for the samples between BWS-11 and BWS-3 along the main channel decease with distance from the tide gates (0.26, 0.15 and 0.07) indicating decreasing impact from Ballona Creek, and localized impact from urban runoff.

The results of the toxicity testing indicate the percent survival was the lowest at stations BWS-9 and BWS-11, with values of 34% and 9%, respectively. Station BWS-9 is the second sampling location from the tide gates to Ballona Creek. The concentrations of metals, pesticides and PCBs in BWS-9 were not significantly greater than the other samples located in the main channel, and the ERM-Q of this sample was 0.26, compare to the ERM-Q of 0.80 at BWS-3 located closest to the tide gate. These results for BWS-9 suggest a possible synergistic effect of the constituents that were detected (many above the ERL as discussed below), or from another possible constituent or physical condition that was not tested or specifically identified as part of this project. Further testing may be needed to determine the cause of the toxicity response.

The toxic response observed for BWS-11 corresponds to detected higher concentrations of metals and several pesticides in this sample. The toxicity results also correspond to the ERM-Q value for this sample, which is the highest of the eleven samples. The results for BWS-11, which is located in a tributary channel adjacent to Culver Blvd., indicate a potential impact from urban runoff that is resulting in toxic response to aquatic organisms.

Comparisons to the more conservative ERL guidelines indicated the greatest number of exceedances observed at Stations BWS-5, -8, -9 and -11. The higher number of exceedances at BWS-11 corresponds to the highest ERM-Q and toxicity response of the sediment samples. As stated above, these results indicated potential impact from urban runoff as this sample is located adjacent to Culver Blvd and is subject to runoff from this roadway. The higher number of exceedances of the conservative ERL at the other locations may be a function of higher clay fraction in the case of BWS-5, and urban runoff/fresh water input at BWS-8. The higher number of exceedances observed at BWS-9, located in the main channel further inland from BWS-3 and the tide gates to the Creek may be due to possible impacts from Ballona Creek. However, a defined concentration gradient for metals is not evident. Furthermore, although a toxic response was observed for the BWS-9 sample, a defined correlations to the constituent concentrations detected is not well evident when compared to the concentrations of these constituents in samples that did not show a toxic response. Further investigation of these results is recommended.

The existing marsh is also not open to full tidal flow, but muted flow controlled by the tide gates. Sediment quality data collected from the Ballona Creek estuary during the 2003 Bight program also shows metals exceedances of copper, lead, and zinc. Higher concentrations than the Ballona Creek sediment samples are observed in sample BWS-11 as presented in Table 3. This samples is likely impacted by urban runoff from Culver Blvd. Higher concentrations were also observed in samples BWS-3, -5, -8 and -9. Cadmium exceeded the ERL at each station sampled within Area B, but did not exceed criteria within Ballona Creek sediments sampled during the 2003 Bight program. It was reported to have exceeded the ERL in Ballona Creek sediments in the draft Total Maximum Daily Load report for Toxic Pollutants in Ballona Creek Estuary (CRWQCB & US EPA, Region IX, 2005). Cadmium has not been found to exceed water quality criteria within Ballona Creek.

Table 3. Range of Values for Constituents Found to Exceed within Ballona Marsh and Ballona Creek Estuary Sediments

	Ballona Marsh		Ballona Creek Estuary Range
	Range	Max	
Metals (mg/kg)			
Arsenic	3.7 – 14.6	BWS-11	2.37 – 4.01
Cadmium	1.83 – 6.16	BWS-11	0.13 – 0.96
Chromium	18 – 70.2	BWS-5	10.6 – 21.9
Copper	17 – 440	BWS-11	10.6 – 36.4
Lead	20.8 – 248	BWS-11	12.7 – 111
Mercury	0.041 – 0.29	BWS-11	0.03 – 0.11
Nickel	9.2 – 38.5	BWS-11	7.6 – 13.3
Selenium	<0.35 – 1.61	BWS-8	NA
Silver	0.27 – 3.77	BWS-5	0.36 – 0.87
Zinc	54.9 – 1770	BWS-11	73.5 – 202
PAHs (mg/kg)			
Total detectable PAHs	0 – 1.5	BWS-11	0.069 – 1.93
Pesticides and PCBs (ug/kg)			
Total detectable DDT	0 – 17.1	BWS-3	0 – 17.3
Total detectable chlordane	0 – 51.4	BWS-3	0 – 21.6
Prowl (Pendimethalin)	<1.8 – 300	BWS-11	NA
Bifenthrin	ND – 34J	BWS-11	NA
Total detectable PCBs	0 – 36	BWS-9	0 – 8

This comparison to the Ballona Creek sediments indicates the following:

- Most of the exceedances of the sediment guidelines within Area B were found in tributaries of the main channel both near the tidal inflow from the creek and at locations that are subject to urban runoff and fresh water flows from groundwater seeps.

- Area B may be acting as a sink for these metals that migrate to Area B in suspended sediment from Ballona Creek. Concentrations are in some locations greater in Area B possibly due to the control of tidal flows that limits the level of circulation and flushing that is observed in the Ballona Creek estuary, even through the creek estuary is subject to greater constituent loading.

- Urban Runoff and aerial deposition from Culvert Blvd. is impacting the sediments in the existing channels adjacent to the primary transportation corridor for Playa del Rey. As presented in Table 3, the majority of the highest concentrations of metals were detected in the sediment at BSW-11 located adjacent to Culver Blvd.

- Urban Runoff from adjacent communities and from portions of Area B that have been filled and subject to agricultural and oil/gas extraction may be contributing to metals concentrations in the channel sediments subject to these flows.

- It appears that metals from Ballona Creek could be accumulating in marsh sediments due to lack of tidal flushing, or there may be a source of metals other than Ballona Creek, such as urban runoff and stormwater flows from Culver Blvd. For constituents such as copper and zinc, where the highest values found in the marsh exceed those found in the creek by up to 10 times, a secondary source seems likely.

Steps Forward

Based on the results and conclusion of this sediment investigation of Area B, the following steps forward are recommended:

1. The benthic data that has been collected by the City of Los Angeles Department of Sanitation should be obtained and compared to the analytical and toxicity testing results from this study in order to determine if there is a correlation between higher constituent concentrations and/or toxicity response to the health of the benthic community. These data provide an additional set of results that will allow for further conclusions on the potential impact of sediments on the restored habitat. Evidence of benthic community impact will confirm results showing exceedances of sediment guidelines and/or toxic responses. These data may also indicate that there is little impact to the benthic community and therefore the chemistry and toxicity data do not provide the full picture with regard to the bioavailability of the constituents detected.

2. Results from Bight03 for other coastal wetlands should be compared to the results from this study to determine the level of impact compared to other wetlands in the region.

3. In order to better assess the potential impact of constituents detected in sediments and on the marsh habitat, tissue sampling and analysis of target species is recommended. Tissue sampling and analysis will provide data on the bioavailability and bioaccumulation of the constituents in the environment. Although several constituents were detected above the sediment guidelines, the actual impact to the species in the marsh needs to be assessed.

4. The alternative development for Area B should consider the evidence of impact from urban runoff and evaluate options to divert and treat these flows prior to their discharge into Area B.

5. Further evaluation of the future contribution/loads of legacy pesticides (chlordane and DDT) in the Ballona Creek estuary and potentially into Area B under muted tidal and full tidal flows should be performed to determine potential long-term impacts to the restored tidal wetlands.

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